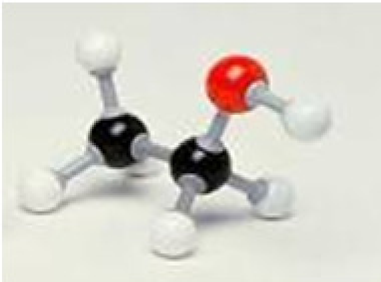

Intensification of bioethanol production

Simultaneous saccharification and fermentation in the oscillatory baffled reactor (OBR)

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Outline

- Introduction
- Motivation
- Oscillatory baffled reactor (OBR)
- Simultaneous saccharification and fermentation (SSF)
- Results
- Conclusion

Introduction

- Energy need has been met principally by the use of fossil fuel resources.
- Combustion of fossil fuels inevitably contributes significantly to global warming.
- Global crude oil reserves are finite.
- Society recognises the need to find renewable alternative energy sources.

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Bioethanol

- Currently the dominant global renewable transport fuel.
- Produced primarily by the microbial fermentation of simple sugars, mostly hexoses from starch or cellulosic materials.
- It offers greenhouse gas savings of up to 80% over conventional fossil fuels.

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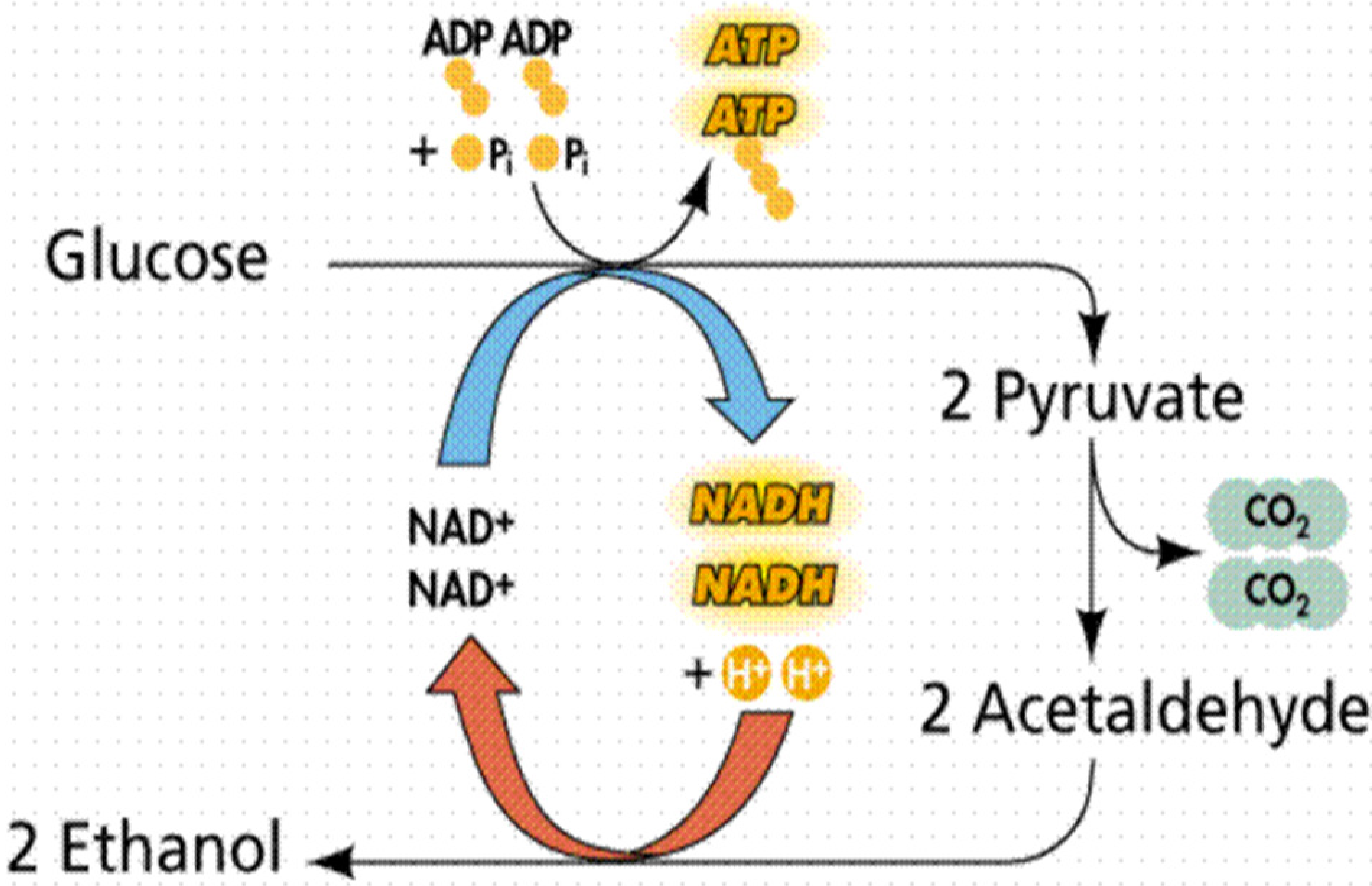

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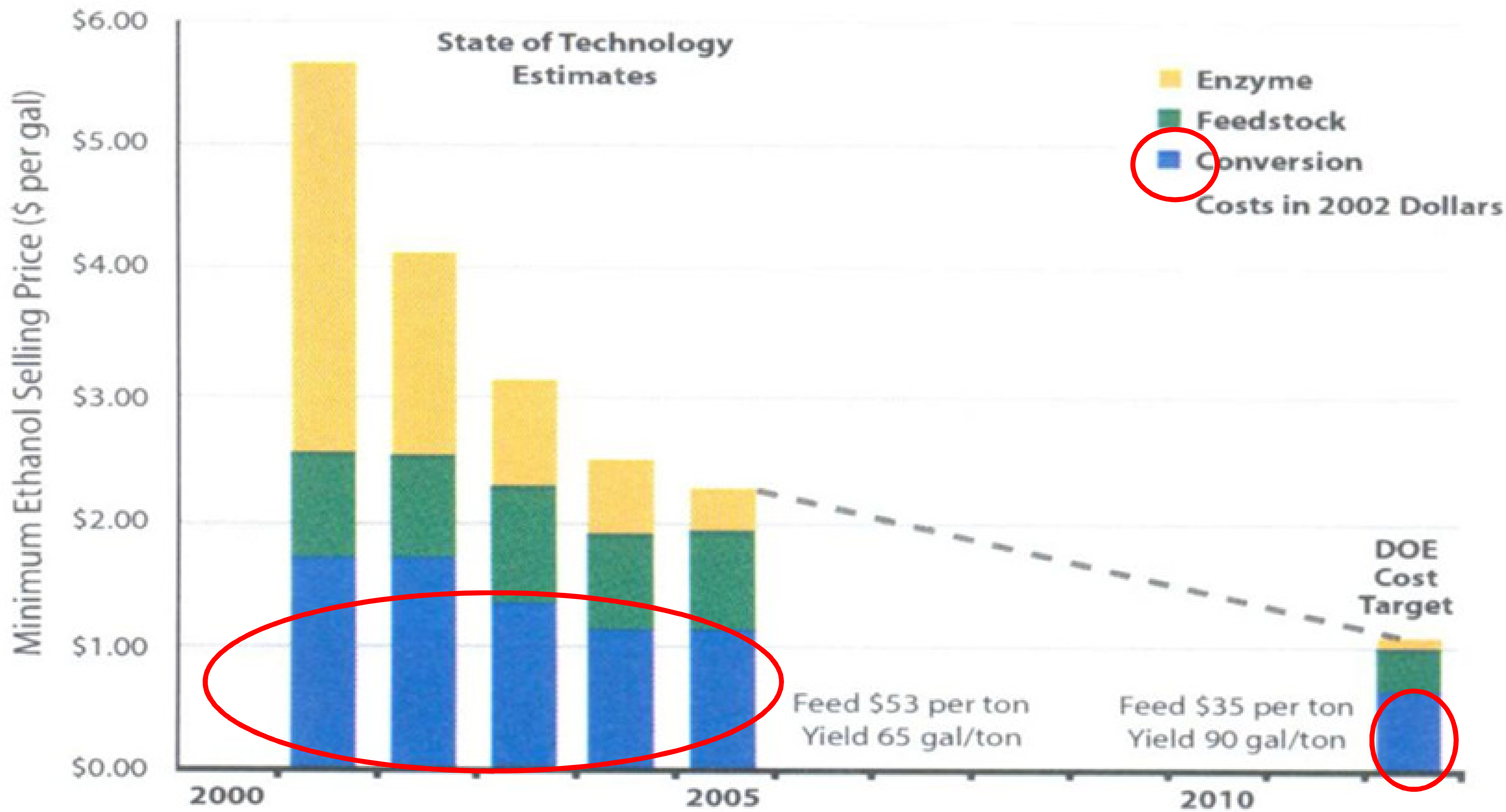
State of technology estimates source: NREL 2009



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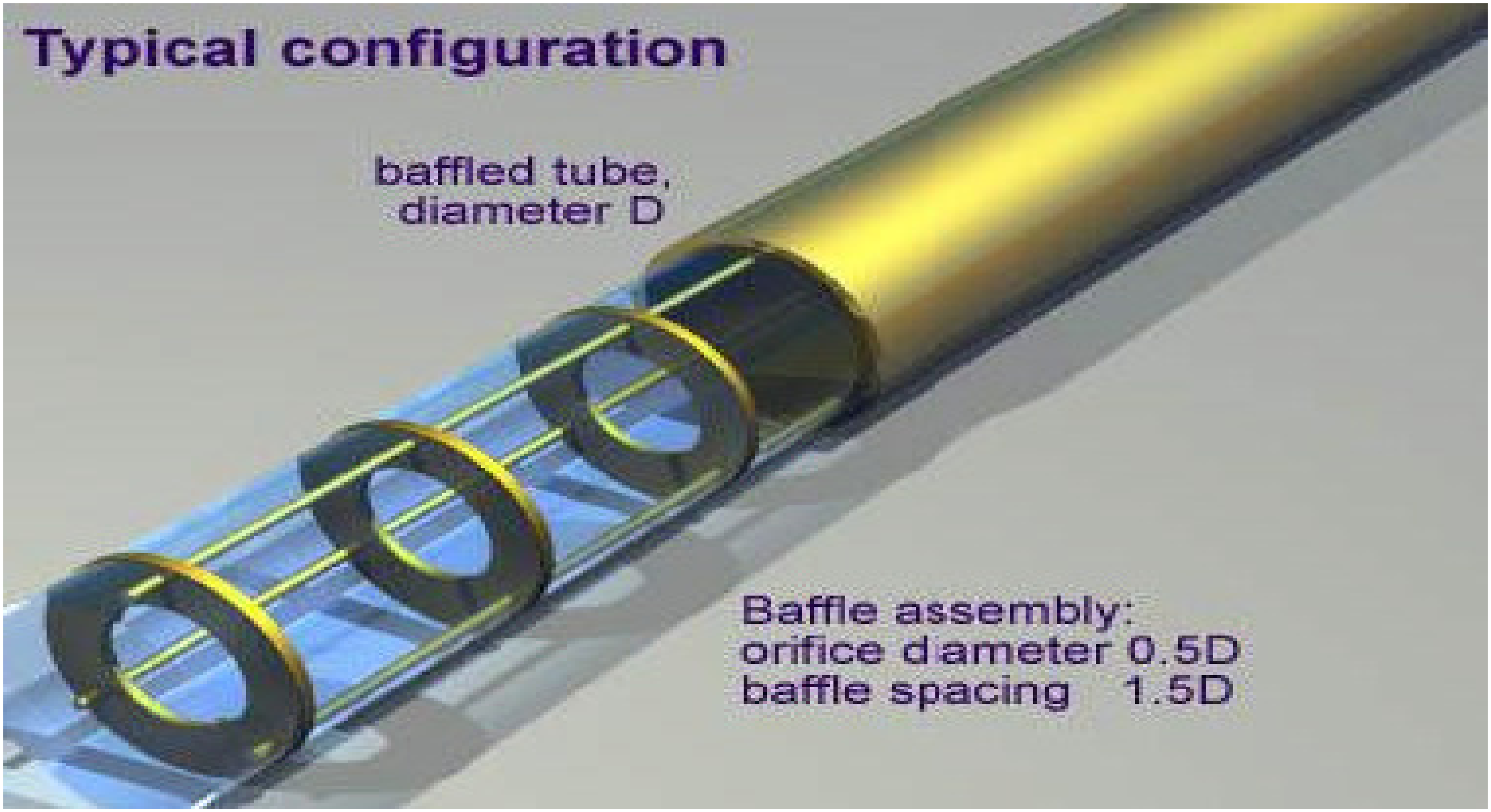
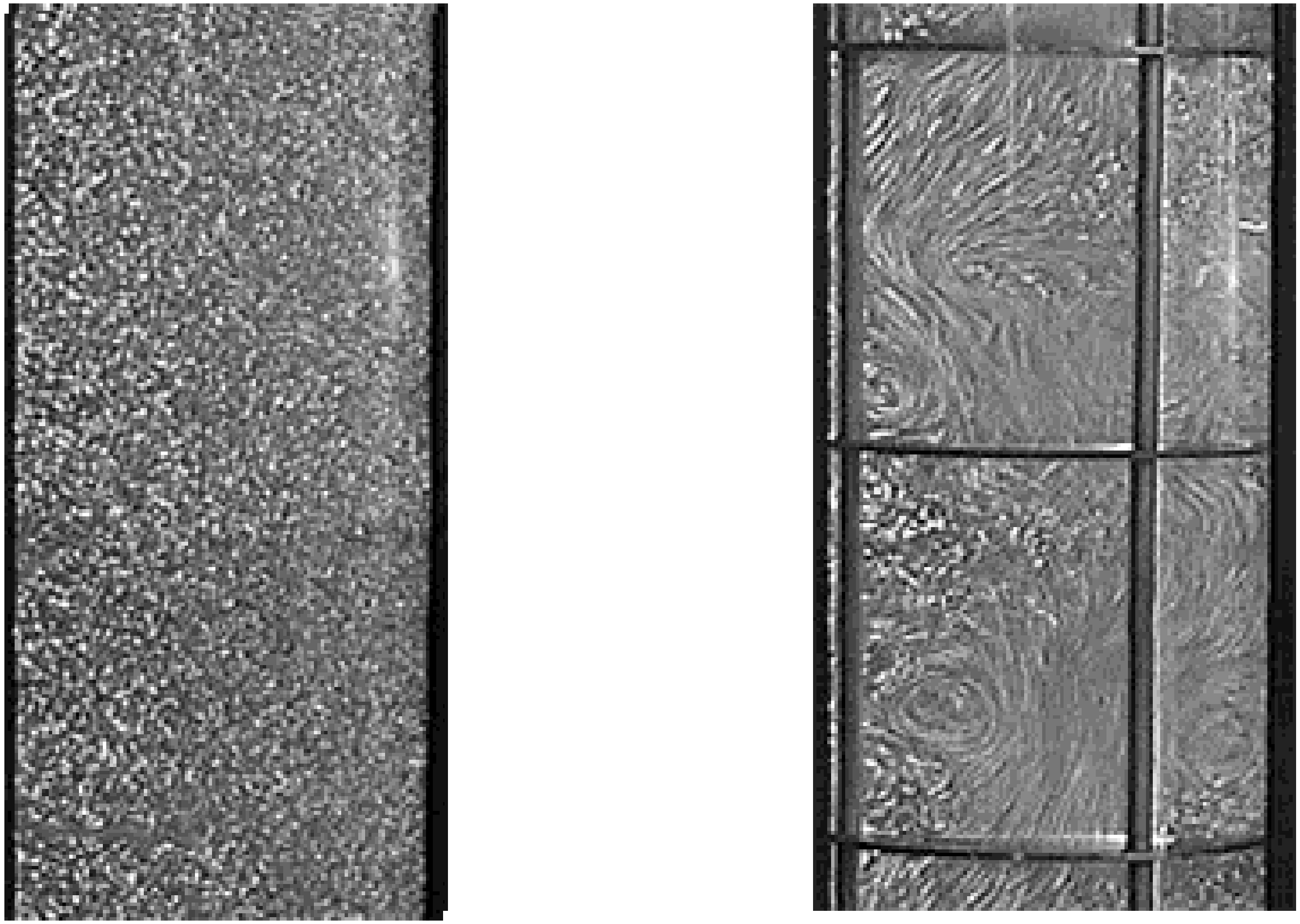
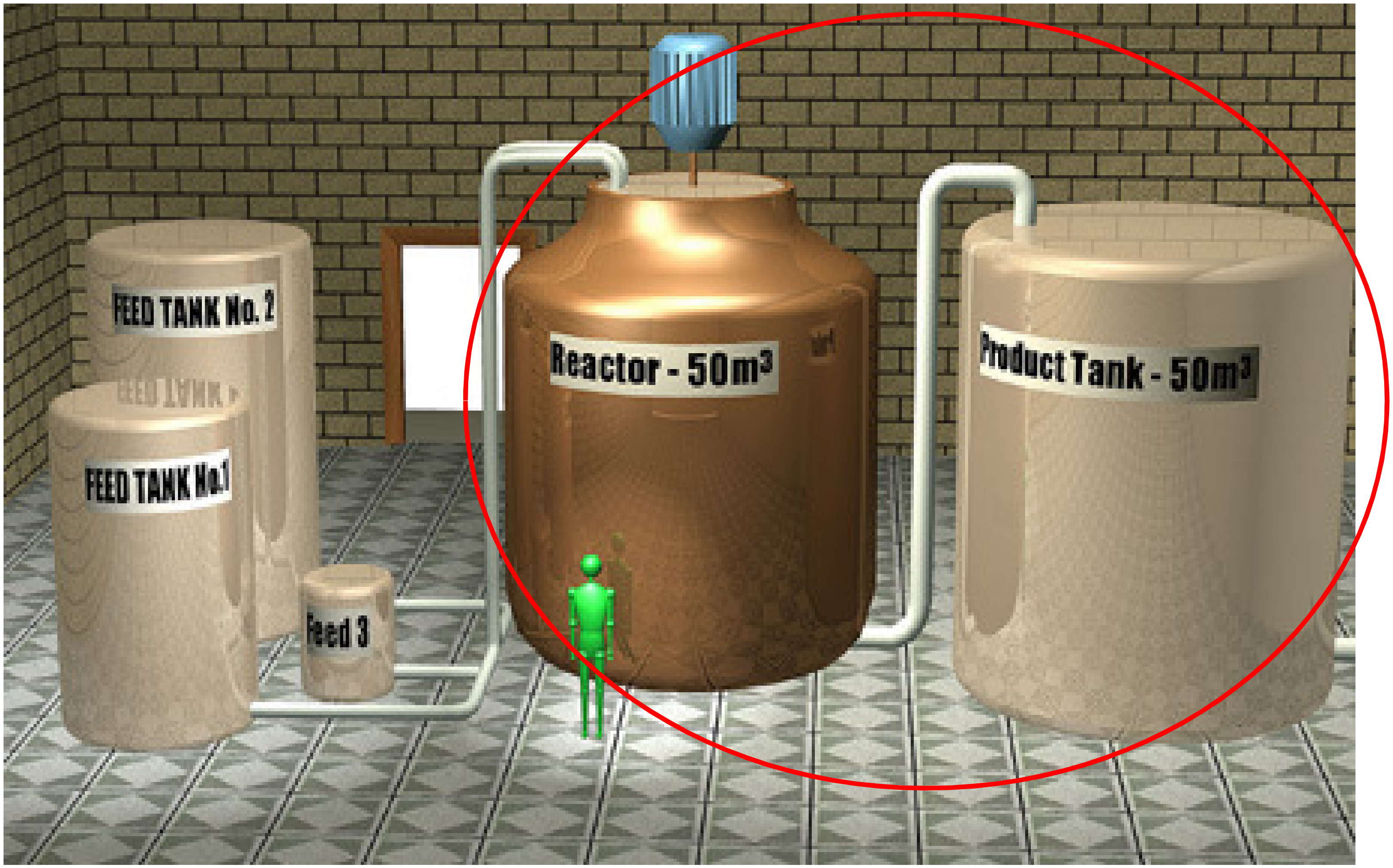
Oscillatory Baffled Reactor (OBR)





Flow patterns in unbaffled and OBR cells

Current technology using batch processing



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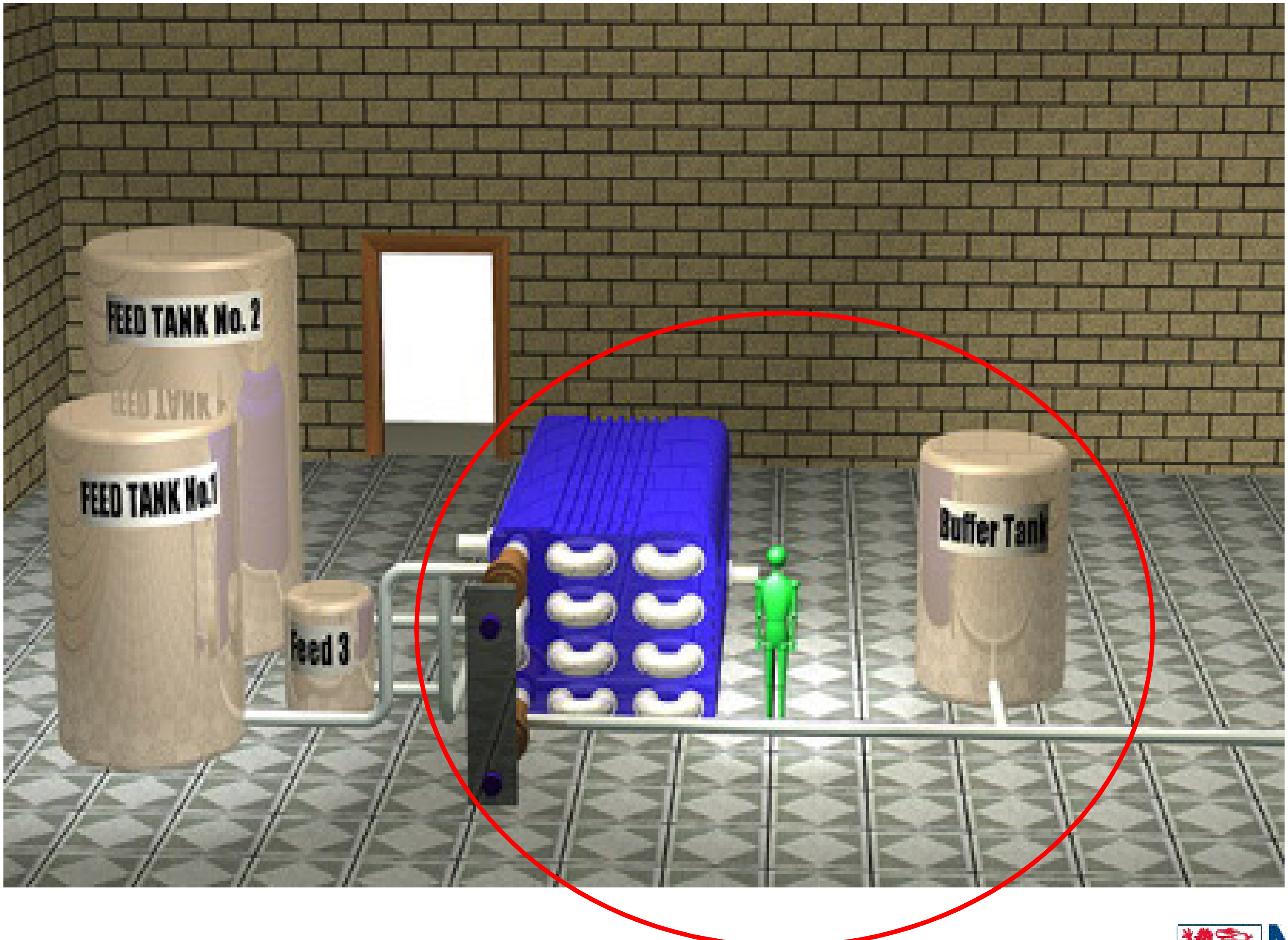
Process Intensification using the OBR



Simultaneous saccharification and fermentation (SSF)

- SSF is a process in which the saccharification and fermentation are combined into one step.
- Better than SHF.

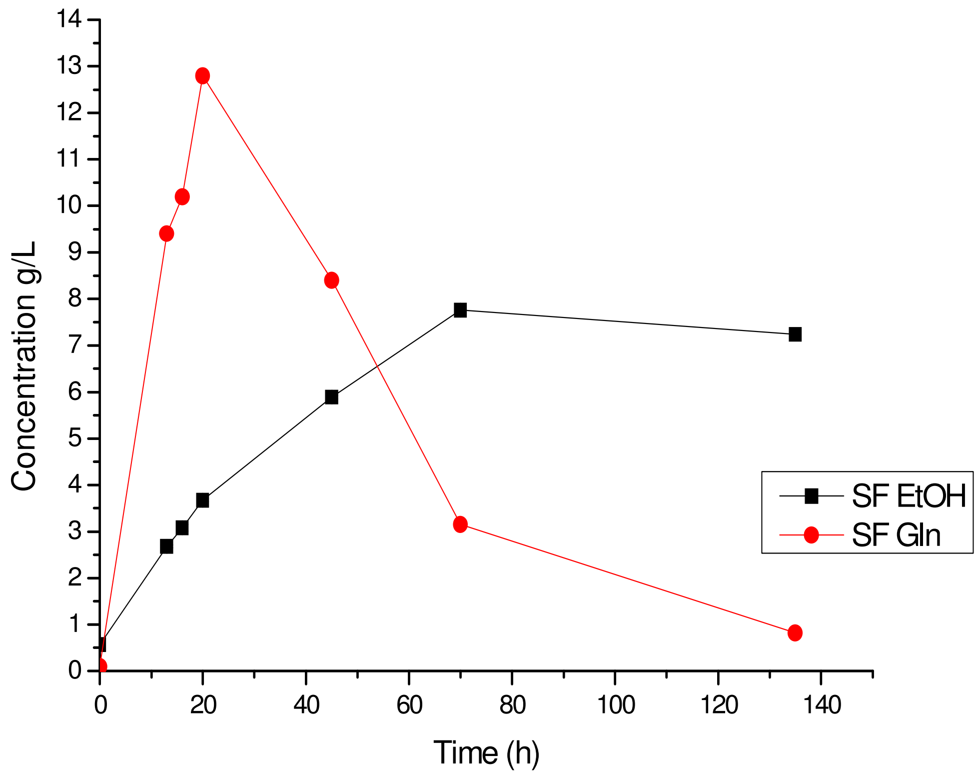
Why?

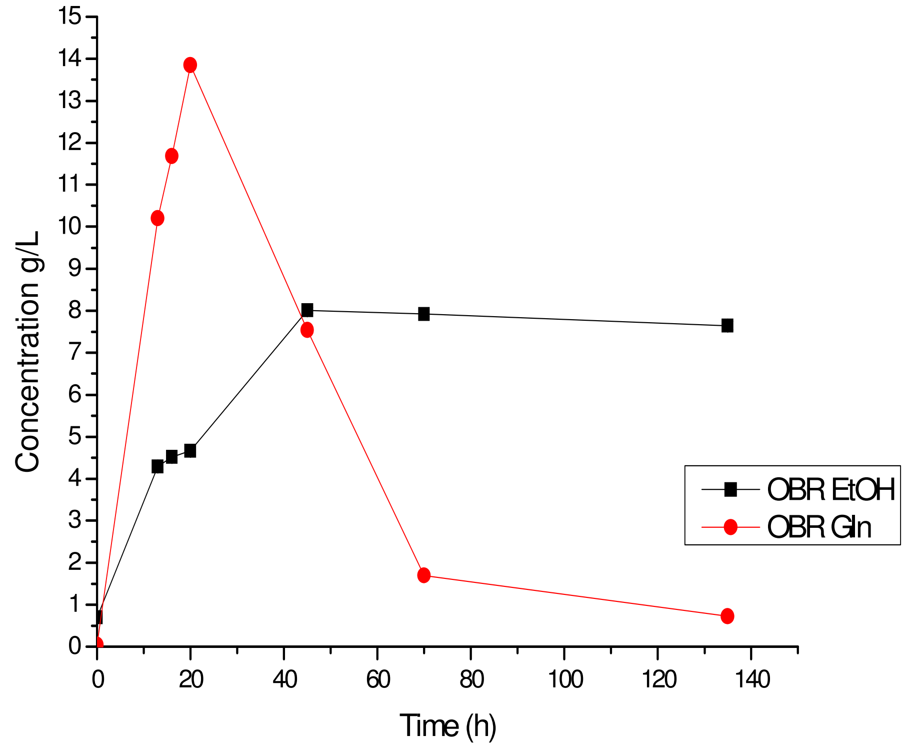
1. Glucose is immediately consumed.
2. Capital cost is reduced, as two process steps in one vessel.

Simultaneous saccharification and fermentation (SSF)

- SSF was carried out in both OBR and shake flasks under the following conditions:
- 38 ^{o}C, pH 4.8
- Microcrystalline cellulose 2.5%
- Cellulase 40 FPU/g cellulose
- B- glucosidase 10% cellulase
- *Saccharomyces cerevisiae* (10% inoculum)
- YP medium (10 g/L yeast extract and 20 g/L peptone)

Ethanol fermentation profile in shake flask and OBR





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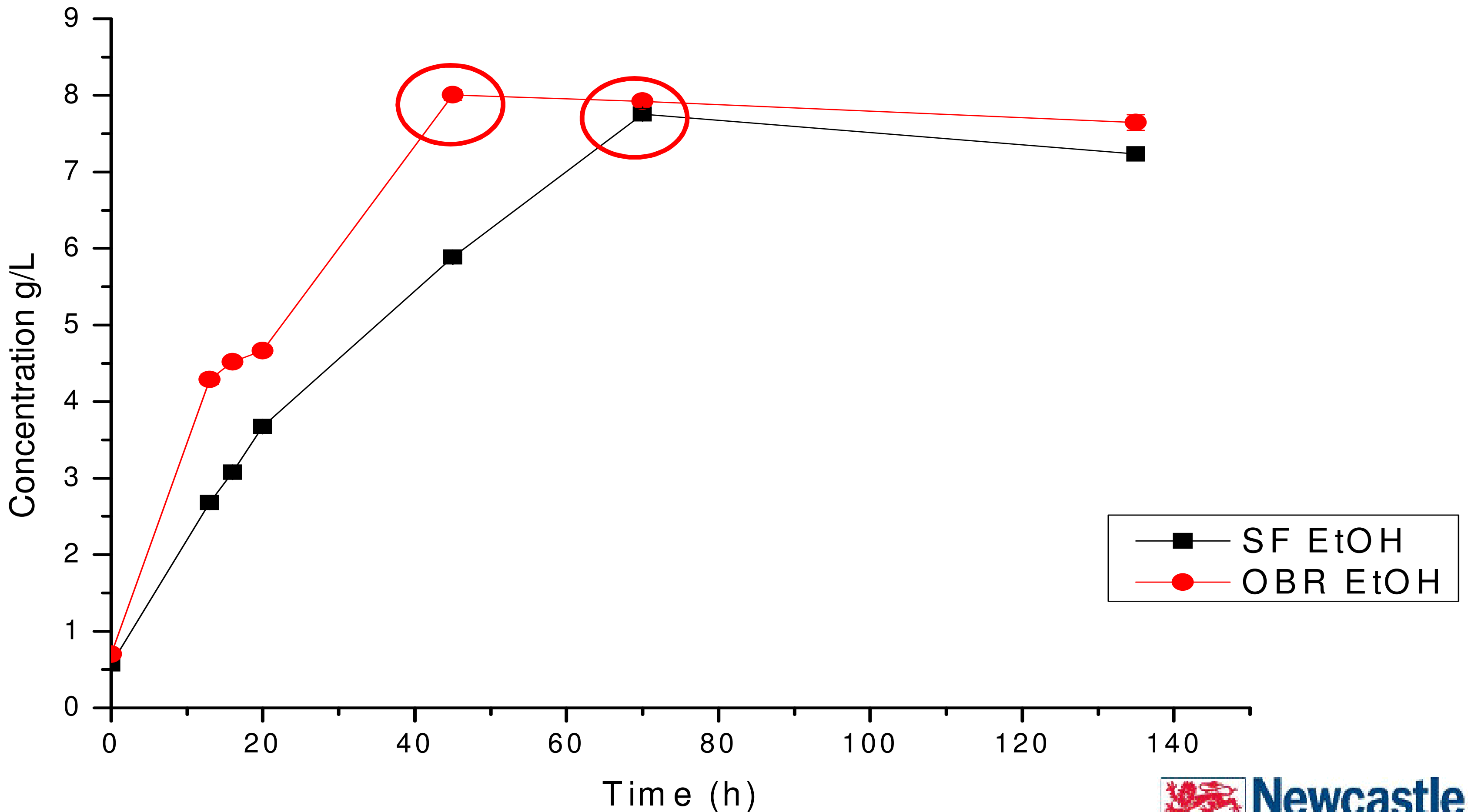
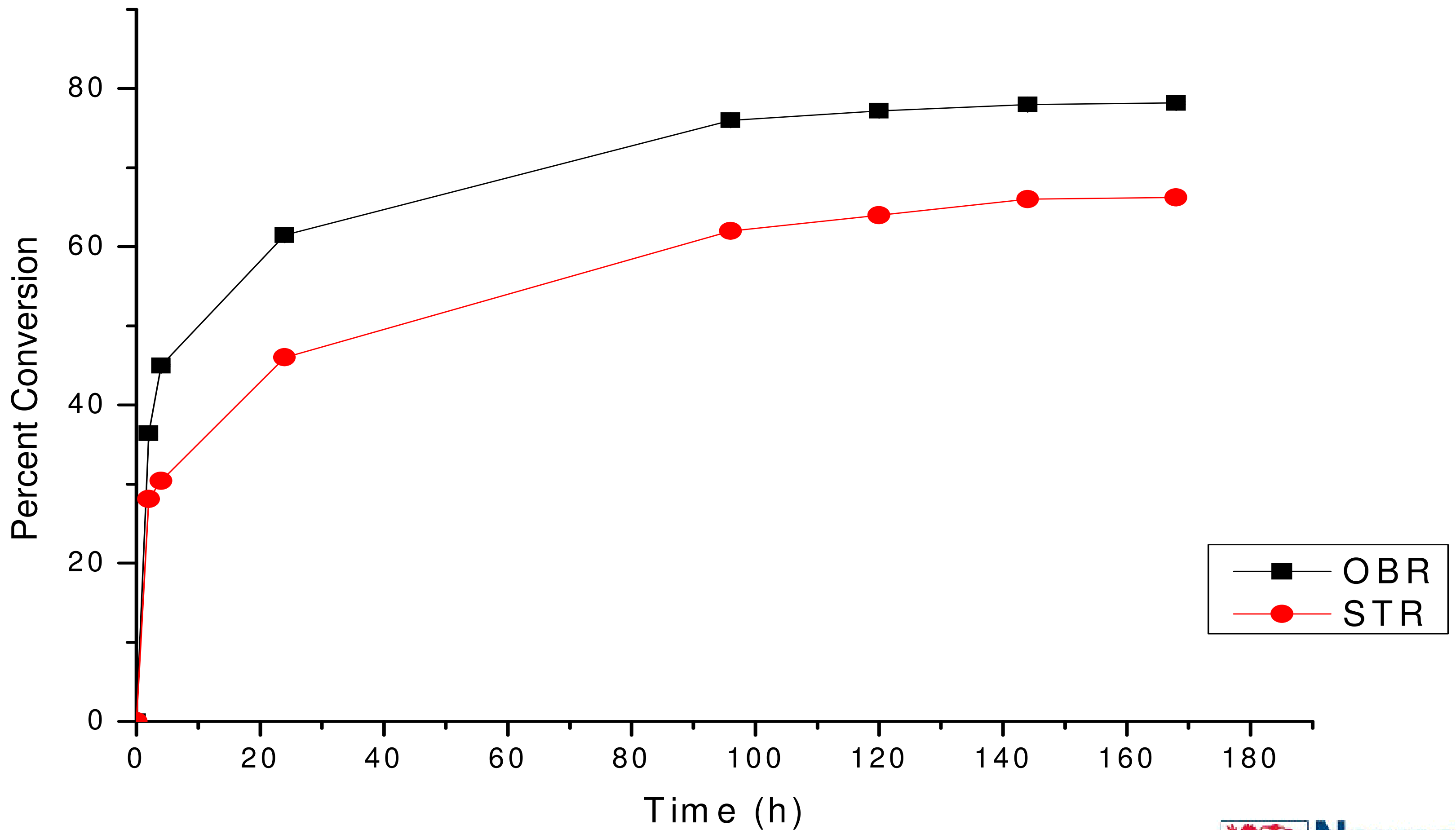
OBR vs Shake flask ethanol profile



OBR vs STR saccharification of 2.5% cellulose at 50 ^{o}C and at 120 Wm^{-3}



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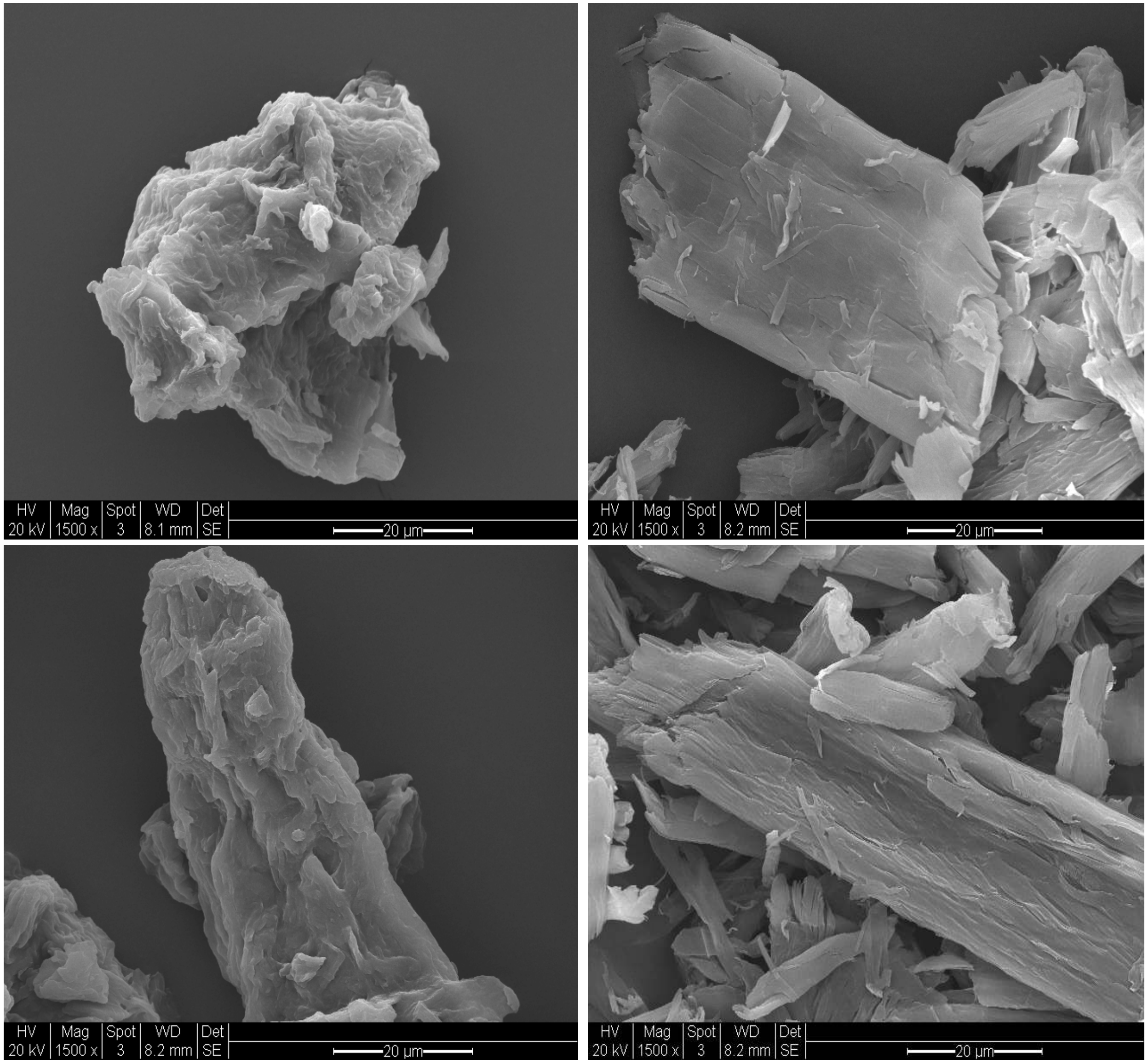
HV 20 kV | Mag 1500 x | Spot 3 | WD 8.1 mm | Det SE
20 µm
HV 20 kV | Mag 1500 x | Spot 3 | WD 8.2 mm | Det SE
20 µm
HV 20 kV | Mag 1500 x | Spot 3 | WD 8.2 mm | Det SE
20 µm
HV 20 kV | Mag 1500 x | Spot 3 | WD 8.2 mm | Det SE
20 µm

OBR vs STR vs Shake flask

	conversion of 2.5% cellulose %	Ethanol g/L	Ethanol yield %	Power density Wm^{-3}
OBR	78	8.0	89.8	120
STR	66	-	-	120
Shake flask	56.2	7.7	81.29	-

Conclusion

- Although the concentration of ethanol from the two systems were similar (8 g/L OBR vs. 7.7 g/L shake flask), the OBR attained this concentration 25 h earlier than the shake flask.
- For the same size of reactor this would lead to a ~30% higher productivity.
- At the same power density, 12% more glucose (g/L) will be available to the yeast in the OBR than in the STR.
- A better mixed SSF environment in the OBR which promoted better mass transfer characteristics was responsible for the increased yield and reduced process time.
- The OBR is linearly scaleable but in conventional STRs reaction times increase with scale, as good mixing becomes increasingly difficult to achieve.
- Minimum shear stress compared to STR, hence suitable for bioprocesses.
- OBR has potential to reduce process times and cost by 50%.

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Thanking you

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